Investigation of the Physical Characteristics of Various Kinds of Wire

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AN INVESTIGATION OF THE PHYSICAL CHARACTERISTICS OF VARIOUS KINDS OF WIRE

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AN INVESTIGATION OF THE PHYSICAL CHARACTERISTICS OF VARIOUS KINDS OF WIRE.

In the preparation of this thesis it has been the purpose of the writers to give a brief outline of the uses, and processes of manufacture of various kinds of wire, and to bring together such information in the form of tables, and experimental data as might be useful as a source of reference to those not thoroughly familiar with the subject of wire.

Before taking up the manufacture of the wire itself, it will be necessary to outline the various methods of treatment to which the iron is subjected before being delivered to the rolling mills. Under this head would be included the manufacture of the following kinds of iron and steel; "puddled iron", "Swedish charcoal iron", "ordinary charcoal iron", "Siemens-Martin" or "open-hearth steel", "crucible cast steel", and "Bessemer steel".

Ordinary puddled iron is produced by refining pig and scrap iron in a reverberatory furnace so as to expel carbonaceous and other impurities. After the metal has been heated for some time and has assumed a more or less fluid or pasty condition, it is worked over and over in the presence of air by means of a special tool, known as a puddler's rake, or "rabble". By

this process the impurities are oxidized and burnt off, and the slag or cinder which always forms is worked into the metal, so that when it comes to be rolled, not only are the impurities very evenly distributed throughout the mass, but it possesses the structure of a bundle of fibres, each one of which is coated with a film of cinder, which protects it in a very large measure from subsequent rusting. Quantities of the pasty metal, termed "balls" or "blooms", are taken out of the furnace on the puddler's rake, and worked under a steam hammer. As soon as the iron has been hammered into a compact mass it is delivered to a "puddle mill", similar to an ordinary train of rolls, where it is rolled into bars or rods preparatory to being annealed and drawn into wire. Bars manufactured by the above process contain 99% iron with only about.3% carbon. The qualtity of this iron may be improved by cutting these bars into suitable lengths, and placing the pieces upon each other in a reheating furnace a process termed "faggotting", where they are raised to a welding heat, and afterward again rolled out into bars. Puddled iron is soft and pliable, but is very inferior material to that known as "charcoal iron".

The best qualities of charcoal iron are made from Swedish pig, which also furnishes the best basis for the manufacture of superior grades of steel. This iron is made from the famous magnetic ores of "Dannemora",

which contain from 30% to 60% metallic iron, in company with sufficient quantities of silica and lime for smelting purposes. The very best charcoal is used in the reduction, and the metal obtained is often so pure, that scarcely a trace of sulphur or phosphorus can be detected. The steel made from this iron is largely used in the manufacture of music and other high grade wire.

Ordinary charcoal iron is produced by a method similar to the puddling process, except that charcoal is used as fuel instead of coke, which imparts some sulphur to the metal. By this treatment one hundred parts of pig iron yields from 85% to 90% of refined iron, the remainder representing impurities.

"Open Hearth Steel" is manufactured by a combination of the "Siemens and Martin" processes, the former consisting of working pig iron with rich oxides, and the latter of melting malleable and pig iron together. In the combined process, pig iron, scrap, rich oxide of iron, and spiegeleisen or ferror-manganeese are fed into an open basin within a reverberatory furnace. A basic lining consisting of carbonate of lime and magnesia, and known as "dolomite", is used in the basin when impure iron is being treated. This absorbs theacid forming impurities, such as phosphorus and sulphur from the iron, the resulting metal being known as "open hearth basic steel". In

case pure iron is fed into the furnace, the basin is usually lined with sand. In this process, the carbon is burned out of the iron, by allowing hot air to play over the surface of the molten mass. The metal is tapped into a ladle from which it is run into ingot molds, and allowed to cool.

A superior product known as crucible cast steel is produced by melting "blister" or "cemented steel" with carbon and manganese in refractory pots or crucibles. The fact that the qualtity of the finished product depends greatly upon the nature and degree of heat used, and the extent of carbonization, and also upon the temperature at which it is poured, makes necessary the employment of experienced men in its manufacture. The capacity of the crucibles used varies from forty to sixty pound charges. Any quality of "blister bar" may be used, but the heat grade of steel is produced from "Swedish blister". "Blister steel" is obtained by heating bars of best malleable iron in contract with charcoal, within a closed chamber or furnace. Crucible cast steel is of an extremely uniform and compact granular texture. Owing to high degree of tenacity, it is almost universally used in the manufacture of plough steel, music, and other high grade wires.

The more modern and extensively used method of making steel, is that known as the "Bessemer process".

Molten cast iron is poured into a large pear-shaped vessel called a "converter", at the bottom of which are a number of small holes, through which a blast of hot air is forced under a high pressure. The carbon and silicon are burned out by this means. When the blow has continued long neough to accomplish the above results, the blast is shut off, and a quantity of spiegeleisen or ferro-manganese is added to the mass, after which it is poured into ingot moulds and allowed to cool. The object of adding ferro-manganese to the molten material is, to reduce or deoxidize the burnt iron, and to prevent the formation of "blow holes" when the metal is poured. It will be noted that the open-hearth and Bessemer processes are somewhat similar. Owing to the large amount of metal which can be worked at each charge, and the simiplicity of operation. Bessemer steel is cheaper than the other grades.

Having discussed the different methods of the manufacture of iron and steel, it might be well at this point, to give a short explanation of the effects of the various elements in these metals. The hardness and elasticity, or the quality of temper of steel depends in a very lagge measure upon the percentage of carbon present; for instance, mild steel usually contains from.1% to.2% carbon, while in hard steel, it may run as high as 1% or even higher. In iron and steel used for wire manufactur-

ing purposes the carbon content may run as follows:

Steel Spring Wire---.4%
Ordinary Rope Wire--.5%
Piano Wire----------.6%
Plough Steel Wire---.8%

The "Tempers", however, depend upon manner of drawing, and also upon the tempering and patenting appliances used in the wire mill. Manganese in quantities ranging from .5% to .7% imparts toughness to steel, and also tends to neutralize brittleness or "shortness". However, it has the detrimental effect of increasing the electrical resistance of the metal, and of causing deterioration by electrolysis, when exposed to moisture. Silicon should be present only in very small quantities, as it tends to produce brittleness, which increases with the percentage of carbon. It is not desirable to have phosphorus or sulphur present in any quantity whatever, as the former produces "cold shortness", and is antagonistic to any form of tempering or conductivity , while the latter causes unsoundness and "red shortness". The expression "shortness", is intended to convey the idea of "brittleness, such as is found in a carot. Other elements such as "chromium", "tungsten", "titanium" and copper are sometimes found in iron and steel, but not in sufficient quantities

to require consideration.

In describing the above processes, the discussion was limited to the manufacture of steel, in the form of "billets" only. From this point on the treatment of the various kinds of steel in the production of wire is very similar, and therefore only one description will be necessary. After being removed from the moulds, the "billets" are raised to a white heat, in a reheating furnace. They are then taken out, rolled to size, and cut into suitable lengths, after which they are delivered to the rod mills. Here they are again heated in a furnace as before, and started through the rolls. At this point, each bar is approximately 4 inches square in cross section, and 4 feet long. The process of rolling is continuous, the bar assuming different shapes of cross section, i. e., "square", "elliptical" and "round" on its way through the train. At various points along the rolls, the bar is automatically twisted, in order to knead the metal. Upon emerging from the main rolls, the rod is received by experienced workmen, who pass it back and forth through smaller rolls, giving it round and elliptical cross-sections alternately, until finally it is delivered and reeled as No. 5 gauge wire rod.

This is then placed in sulphuric acid vats until clean, after which it is subjected to a hot lime-water

bath, in order to remove the acid, and finally is baked for half a day preparatory to being drawn. The purpose of the lime coating is to act as a lubricant and prevent cutting out of the dies. The rod is then drawn cold through a series of suitable dies until it is reduced to wire of the desired diameter. The number of times which it is annealed during this process depends upon the finished size, and also upon the use to which it is to be put. The dies used in the drawing of all ordinary wire consist merely of hardened steel blocks, through which are holes of the proper diameter. They are held in vice like clamps, and are easily detachable. The method of drawing the wire through these dies is as follows: The end of the rod is reduced by hammering to such a size, that it will easily slip through the die. It is then gripped by a jaw, which automatically draws it through the die until such a length is obtained as will permit its being started on a reel. The reel is then started and continues to revolveuntil the entire length of wire has been drawn through the die. In the drawing of the more precious metals, such as "gold", "silver" and "platinum", jewel dies are used in place of steel.

The process of annealing the larger sizes of wire consists of drawing it through long brick tubes, which are heated by gas or coal. In the case of small

wires, however, the above method is not applicable, because of the liability to stretch upon attaining a red heat, therefore, it is annealed by placing the coils in large iron pots and heating them.

In galvanizing wire, it is first heated, by being passed through a small furnace, then through a "pickling solution", generally diluted muriatic acid, then through a bath of melted zinc, and finally through a bank of damp charcoal or asbestos wipers, to smooth off the coating. The charcoal is used in the case of telephone and telegraph wires, and gives what is known, as "double galvanizing, while the asbestos is used for fence and other wire, upon which only a thin coating is necessary. The zinc or "spelter", generally employed in this process, consists of about 99% pure zinc, .1% iron, .5% lead, and sometimes small quantities of other elements, depending upon the quality of the ore used. Tinned wire is prepared in a very similar manner, with the exception, that tin is used as a coating in the place of zinc.

There are various methods of tempering wire, but the one most generally employed, is that of the "oil bath". Here it is heated then hardened, by being passed under a stream of oil, and finally the desired degree of "temper" is obtained, by means of a "lead bath". Many ordinary wires are sufficiently hardened in the

process of drawing, so that no additional temper is necessary.

Having covered in general way the manufacture of wire, the results of tests, and an explanation of the accompanying tables will now be given. The possibilities of investigation along the line of expermental work were found to be so broad, that it was necessary to confine tests to three classes of wire, i. e., "Steel Piano Wire", "Galvanized Iron" and "Steel Telephone Wire", and "Ordinary Iron and Steel Wire". These will be taken up in the above order. In each case, five samples of approximately 18 inches in length, of each size were used, the elongation in 12 inches being measured. In testing the smaller sizes of wire a 10000 lb. capacity Olsen wire testing machine was used, while for the larger sizes, a 60000 lb. capacity Olsen Power machine was used.

PIANO WIRE.

Samples of piano wire from the three following manufacturers were very kindly furnished by the "Kimball Piano Company", and were used in the tests: "Pohlmann Wire Company"., "Felton & Guilleaume Wire Company", and the "American Steel & Wire Company". In making the tests, the wire was caught in the machine, and a suffi-

cient load applied, to take out the slack. Two small brass clamps were then placed on the wire, at a distance of 12 inches apart, and a 24 inch scale was used, to note any elongation in the wire, as the load was increased. The total elongation was taken as the difference between the first and final readings. The figures given in the table are average results of the five tests. It will be noted, that there is some discrepancy in the maximum streigth in pounds per square inch. In all probability, this is due to the fact, that there was a noticable variation in the diameter of the samples at different points.

GALVANIZED IRON AND STEEL TELEPHONE WIRE.

The tensile tests upon this class of wire were conducted in a manner similar to those on "Piano Wire", with the exception, that the elongation in this case was measured between two marks on the wire. This wire was subjected to the standard torsion and galvanizing tests. The former consists of holding a wire in two vices six inches apart, and turning one of them. The total number of twists must not be less than fifteen. The latter consists of immersing the wire into a saturated solution of "sulphate of copper", and permitting it to remain one

minute, when it is taken out and wiped clean. This process is performed four times, and if the wire appears black after the fourth immersion, the galvanizing is well done.

These samples fully complied with all of the specifications of both of these tests. The wire was electrically tested for resistance, the results of which tests may be seen in the table.

"The Indiana Steel & Wire Company", furnished the three grades of wire used in these tests.

INDEX TO TABLES.

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Number of Wire Gauge.
6 - 0
5 - 0
4 - 0
3 - 0
2 - 0
1 - 0
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TABLE No. 1

WIRE GAUGES COMPARED

SIZES IN DECIMAL PARTS AND MILLIMETERS.

Number Of Wire Gauge.	American or Brown & Sharpe.		W. & M., Roebling, S. W. Co.		Old English or London.		Birmingham or Stubbs.		English Legal Standard.		Trenton Wire Gauge.	
	In.	MM.	In.	MM.	In.	MM.	In.	MM.	In.	MM.	In.	MM.
6 - 0			.4615	11.683					.464	11.785		
5 - 0			.4305	10.921					.432	10.972	.450	11.430
4 - 0	.46000	11.683	.3938	9.982	.4540	11.531	.454	11.531	.400	10.160	.400	10.16
3 - 0	.40964	10.404	.3625	9.195	.4250	10.795	.4250	10.794	.372	9.448	.360	9.144
2 - 0	.36480	9.266	.3310	8.407	.3800	9.652	.3800	9.652	.348	8.839	.330	8.382
1 - 0	.32495	8.251	.3075	7.798	.3400	8.636	.3400	8.636	.324	8.229	.305	7.747
1	.28930	7.348	.2830	7.188	.3000	7.620	.3000	7.620	.300	7.620	.285	7.239
2	.25763	6.544	.2625	6.680	.2840	7.2136	.2840	7.213	.276	7.010	.265	6.731
3	.22942	5.827	.2437	6.198	.2590	6.5786	.2590	6.579	.252	6.401	.245	6.223
4	.20431	5.190	.2253	5.715	.2380	6.0452	.2380	6.045	.232	5.893	.225	5.715
5	.18194	4.621	.2070	5.257	.2200	5.588	.2200	5.588	.212	5.385	.205	5.207
6	.16202	4.115	.1920	4.877	.2030	5.1562	.2030	5.156	.192	4.877	.190	4.826
7	.14428	3.665	.1770	4.496	.1800	4.572	.1800	4.572	.176	4.470	.175	4.445
8	.12849	3.263	.1620	4.115	.1650	4.1910	.1650	4.191	.160	4.064	.160	4.064
9	.11443	2.906	.1483	3.759	.1480	3.7592	.1480	3.759	.144	3.657	.145	3.683
10	.10189	2.588	.1350	3.429	.1340	3.4036	.1340	3.404	.128	3.251	.130	3.302
11	.09074	2.305	.1205	3.048	.1200	3.048	.1200	3.048	.116	2.947	.1175	2.9845
12	.08081	2.052	.1055	2.667	.1090	2.7686	.1090	2.768	.104	2.641	.1050	2.6670
13	.07196	1.828	.0915	2.337	.0950	2.413	.0950	2.413	.092	2.337	.0925	2.349
14	.06408	1.628	.0800	2.032	.0830	2.1082	.0830	2.108	.080	2.032	.0800	2.0320
15	.05707	1.449	.0720	1.829	.0720	1.8288	.0720	1.829	.072	1.829	.0700	1.7780
16	.05082	1.291	.0635	1.600	.0650	1.6510	.0650	1.651	.064	1.626	.0610	1.5494
17	.04526	1.150	.0540	1.372	.0580	1.4732	.0580	1.473	.056	1.422	.0525	1.3335
18	.04030	1.024	.0475	1.194	.0490	1.2446	.0490	1.245	.048	1.219	.0450	1.1430
19	.03589	.9116	.0410	1.041	.0400	1.016	.0420	1.067	.040	1.016	.0400	1.0160
20	.03195	.8118	.0348	.8890	.0350	.8890	.0350	.8890	.036	.9144	.0350	.8890

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Number of Wire Gauge.
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TABLE No. 1

(Concluded)

Number Of Wire Gauge.	American or Brown & Sharpe.		W. & M., Roebling, S. W. Co.		Old English or London.		Birmingham or Stubbs.		English Legal Standard.		Trenton Wire Gauge.	
	In.	MM.	In.	MM.	In.	MM.	In.	MM.	In.	MM.	In.	MM.
21	.02846	.7229	.03175	.8128	.0315	.8001	.0320	.8128	.032	.8128	.0310	.7874
22	.025347	.6438	.0286	.7112	.0295	.7493	.0280	.7112	.028	.7112	.0280	.7112
23	.022571	.5733	.0258	.6350	.0270	.6858	.0250	.6350	.024	.6096	.0250	.6350
24	.020100	.5105	.0230	.5842	.0250	.6350	.0220	.5588	.022	.5588	.0225	.5715
25	.017900	.4546	.0204	.5080	.0230	.5842	.0200	.5080	.020	.5080	.0200	.5080
26	.01594	.4049	.0181	.4572	.0205	.5207	.0180	.4572	.018	.4572	.0180	.4572
27	.014195	.3605	.0173	.4318	.01875	.4762	.0160	.4064	.0164	.4166	.0170	.4318
28	.012641	.3211	.0162	.4064	.01650	.4191	.0140	.3556	.0148	.3759	.0160	.4064
29	.011257	.2859	.0150	.3810	.01550	.3937	.0130	.3302	.0136	.3454	.0150	.3810
30	.010025	.2545	.0140	.3556	.01375	.3492	.0120	.3048	.0124	.3150	.0140	.3556
31	.008928	.2267	.0135	.3429	.01225	.3111	.0100	.2540	.0116	.2946	.0130	.3302
32	.007950	.2019	.0128	.3302	.01125	.2857	.0090	.2286	.0108	.2743	.0120	.3048
33	.007080	.1798	.0118	.2794	.01025	.2603	.0080	.2032	.0100	.2540	.0110	.2794
34	.00630	.1601	.0104	.2540	.00950	.2413	.0070	.1778	.0092	.2337	.0100	.2540
35	.00561	.1426	.0095	.2413	.00900	.2286	.0050	.1270	.0084	.2134	.0095	.2413
36	.00500	.1270	.0090	.2283	.00750	.1905	.0040	.1016	.0076	.1930	.0090	.2286
37	.00445	.1130	.0085	.2159	.00650	.1651	.	.	.0068	.1727	.0085	.2159
38	.003965	.1007	.0080	.2032	.00575	.1460	.	.	.0060	.1524	.0080	.2032
39	.003531	.08968	.0075	.1905	.00500	.1270	.	.	.0052	.1320	.0075	.1905
40	.003144	.07985	.0070	.1778	.00450	.1143	.	.	.0048	.1219	.0070	.1778

. & M., bebling r S. W. Gauge.
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TABLE No. 2

PROPERTIES OF STEEL WIRE.

W. & M., Roebling Or S. W. Gauge.	Diameter In Decimal Parts of An Inch.	Area In Square Inches.	Pounds Per Foot.	Pounds Per 100 Feet.	Feet Per Pound.	Feet Per 2,000 Pounds.	Breaking Strain 100000 Pounds Per Square Inch.
7 - 0	.4900	.18857	.6363	63.63	1.51	3023.	
6 - 0	.4615	.16728	.5608	56.08	1.78	3566.	16619.
5 - 0	.4305	.14556	.4901	49.01	2.04	4081.	14522.
4 - 0	.3938	.12180	.4094	40.94	2.44	4885.	12130.
3 - 0	.3625	.10321	.3473	34.73	2.87	5758.	10292.
2 - 0	.3310	.086049	.2904	29.04	3.44	6887.	8605.
1 - 0	.3065	.073782	.2497	24.97	4.00	8011.	7402.
1	.2830	.062902	.2123	21.23	4.71	9420	6290.
2	.2625	.054119	.1834	18.34	5.45	10905.	5433.
3	.2437	.046645	.1578	15.78	6.33	12674.	4676.
4	.2253	.039867	.1342	13.42	7.45	14903.	3976.
5	.2070	.033654	.1135	11.35	8.81	17621.	3365.
6	.1920	.028953	.0977	9.77	10.23	20741.	2895.
7	.1770	.024606	.0830	8.30	12.04	24096.	2461.
8	.1620	.020612	.0696	6.96	14.36	28735.	2061.
9	.1483	.017273	.0580	5.80	17.24	34482.	1720.
10	.1350	.014314	.0483	4.83	20.76	41408.	1431.
11	.1205	.011404	.0382	3.82	26.17	52356.	1131.
12	.1055	.0087417	.0292	2.92	34.24	68493.	866.
13	.0915	.0065755	.0224	2.24	44.64	89286.	665.
14	.0800	.0050266	.0169	1.69	59.17	118343.	503.
15	.0720	.0040715	.0137	1.37	72.99	145985.	407.
16	.0625	.0030680	.0105	1.05	95.23	190476	312.
17	.0540	.0022902	.00772	.772	129.53	259068.	229.
18	.0475	.0017721	.00585	.585	170.94	341882.	174.
19	.0410	.0013203	.00445	.445	224.71	449438.	132.
20	.0348	.00095115	.00324	.324	308.66	617328.	96.

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TABLE No. 2

(Concluded)

W. & M., Roebling Or S. W. Gauge.	Diameter In Decimal Parts of An Inch.	Area In Square Inches.	Pounds Per Foot.	Pounds Per 100 Feet.	Feet Per Pound.	Feet Per 2,000 Pounds.	Breaking Strain 100000 Pounds Per Square Inch.
21	.0317	.00078924	.00271	.271	369.00	738008.	80.
22	.0286	.00064242	.00207	.207	483.09	966184.	62.
23	.0258	.00052279	.00165	.165	606.06	1212120.	49.
24	.0230	.00041548	.00140	.140	714.28	1428570.	42.
25	.0204	.00032685	.00106	.106	943.39	1886792.	31.
26	.0181	.00025730	.00085	.085	1176.47	2352940.	25.
27	.0173	.00023506	.00076	.076	1315.79	2631580.	23.
28	.0162	.00020612	.00067	.067	1492.54	2985080.	20.
29	.0150	.00017671	.00059	.059	1694.91	3389820.	18.
30	.0140	.00015394	.00051	.051	1960.78	3921560.	15.
31	.0132	.00013685	.00048	.048	2083.34	4166680.	14.
32	.0128	.00012868	.00044	.044	2272.73	4545460.	13.
33	.0118	.00010936	.00032	.032	3125.00	6250000.	9.5
34	.0104	.000084949	.00026	.026	3846.15	7692300.	7.9
35	.0095	.000070882	.00023	.023	4347.82	8695640.	7.1
36	.0090	.000063617	.00021	.021	4761.91	9523820.	6.4

This table of Breaking Strain is calculated on a basis of 483.84 lbs. per Cubic foot of Steel Wire, and the breaking strains are calculated for 100,000 lbs. per square inch simply for convenience, so that the breaking strains of wires of any strength per square inch may be determined by multiplying the values above given in table by ratio between the tested strength per square inch and 100,000.

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TABLE No. 3

SIZES, WEIGHTS, LENGTHS AND STRENGTHS OF IRON WIRE.

Number. Trenton Wire Gauge.	Diameter In Decimal Parts of An Inch.	Area In Square Inches.	Feet Per Pound.	Pounds Per Mile.	Approximate Tensile Strength of Charcoal Iron Wire in Pounds.	
					Bright.	Annealed.
5 - 0	.450	.15904	1.863	2833.248	12598.	9449.
4 - 0	.400	.12566	2.358	2238.878	9955.	7466.
3 - 0	.360	.10179	2.911	1813.574	8124.	6091.
2 - 0	.330	.08553	3.465	1523.861	6880.	5160.
1 - 0	.305	.07306	4.057	1301.678	5926.	4445.
1	.285	.06379	4.645	1136.678	5226.	3920.
2	.265	.05515	5.374	982.555	4570.	3425.
3	.245	.04714	6.286	839.942	3948.	2960.
4	.225	.03976	7.454	708.365	3374.	2530.
5	.205	.03301	8.976	588.139	2839.	2130.
6	.190	.02835	10.453	505.084	2476.	1860.
7	.175	.02405	12.322	428.472	2133.	1600.
8	.160	.02011	14.736	358.3008	1813.	1360.
9	.145	.01651	17.950	294.1488	1507.	1130.
10	.130	.01327	22.333	236.4384	1233.	925.
11	.1175	.01084	27.340	193.1424	1010.	758.
12	.1050	.00866	34.219	154.2816	810.	607.
13	.0925	.00672	44.092	119.7504	631.	473.
14	.0800	.00503	58.916	89.6016	474.	356.
15	.0700	.00385	76.984	68.5872	372.	280.
16	.0610	.00292	101.488	52.0080	292.	220.
17	.0525	.00216	137.174	38.4912	222.	165.
18	.0450	.00159	186.335	28.3378	169.	127.
19	.0400	.0012566	235.084	22.3872	137.	103.
20	.0350	.0009621	308.079	17.1389	107.	80.
21	.0310	.0007547	392.772	13.4429		
22	.0280	.0006157	481.234	10.9718		
23	.0250	.0004909	603.863	8.7437		
24	.0225	.0003976	745.710	7.0805		
25	.0200	.0003142	943.396	5.5968		

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TABLE No. 3

(Concluded)

Number. Trenton Wire Gauge.	Diameter In Decimal Parts of An Inch.	Area In Square Inches.	Feet Per Pound.	Pounds Per Mile.	Approximate Tensile Strength of Charcoal Iron Wire in Pounds.	
					Bright.	Annealed.
26	.0180	.0002545	1164.689	4.5334		
27	.0170	.0002270	1305.670	4.0439		
28	.0160	.0002011	1476.869	3.5819		
29	.0150	.0001767	1676.989	3.1485		
30	.0140	.0001539	1925.321	2.7424		
31	.0130	.0001327	2232.653	2.3649		
32	.0120	.0001131	2620.607	2.0148		
33	.0110	.0000950	3119.092	1.6928		
34	.0100	.00007854	3773.584	1.3992		
35	.0095	.00007088	4182.508	1.2624		
36	.0090	.00006362	4657.728	1.1336		
37	.0085	.00005675	5222.035	1.0111		
38	.0080	.00005027	5896.147	.89549		
39	.0075	.00004418	6724.291	.78672		
40	.0070	.00003848	7698.253	.68587		

N O T E :

The above figures on tensile strength are based upon tests made with good charcoal iron wire from Trenton's blooms.

The tensile strength of wire made of:-

Good refined iron is about 15% less;
Swedish charcoal iron wire is about 10% less;
Mild Bessemer steel is about 10% more;
Ordinary Crucible steel is about 25% more;
Special Crucible steel is from 30% to 120% more;

than that of charcoal iron wire.

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TABLE No. 4

WEIGHT OF ALUMINUM, WROUGHT IRON, STEEL, COPPER AND BRASS WIRE.

Number of Gauge B.& S.	Diameter in Inches.	Weight per One Thousand Lineal Feet.				
		Aluminum.	Wrought Iron.	Steel.	Copper.	Brass.
4 - 0	.460	192.86	553.97	565.50	642.68	615.21
3 - 0	.40964	152.94	439.33	448.45	509.32	487.92
2 - 0	.36480	121.28	348.40	355.65	404.20	386.94
1 - 0	.32486	96.18	276.30	282.02	320.50	306.83
1	.28930	76.29	219.11	223.68	254.20	243.35
2	.25763	60.50	173.78	177.38	201.60	192.98
3	.22942	47.97	137.80	140.67	159.86	153.02
4	.20431	38.05	109.28	111.57	126.78	121.37
5	.18194	30.17	86.68	88.46	100.54	96.26
6	.16202	23.93	68.73	70.15	79.72	76.32
7	.14428	18.98	54.43	55.56	63.23	60.53
8	.12849	15.05	43.23	44.12	50.14	48.00
9	.11443	11.93	34.26	34.99	39.77	38.07
10	.10189	9.462	27.18	27.74	31.53	30.18
11	.090742	7.505	21.56	22.01	25.01	23.94
12	.080808	5.952	17.10	17.46	19.83	18.99
13	.071961	4.720	13.56	13.84	15.73	15.06
14	.064084	3.743	10.75	10.98	12.47	11.94
15	.057068	2.968	8.526	8.704	9.890	9.468
16	.050820	2.354	6.761	6.903	7.843	7.508
17	.045257	1.867	5.362	5.474	6.220	5.955
18	.040303	1.480	4.252	4.342	4.933	4.723
19	.035890	1.174	3.372	3.443	3.912	3.755
20	.031961	.9310	2.672	2.730	3.102	2.970
21	.028462	.7382	2.121	2.165	2.460	2.355
22	.025347	.5855	1.682	1.717	1.951	1.868
23	.022571	.4643	1.333	1.361	1.547	1.481
24	.020100	.3682	1.058	1.080	1.227	1.175
25	.017900	.2920	.8388	.8563	.9731	.9316

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TABLE No. 4

(Concluded)

Number of Gauge B.& S.	Diameter In Inches.	Weight per One Thousand Lineal Feet.				
		Aluminum.	Wrought Iron.	Steel.	Copper.	Brass.
26	.015940	.2316	.6652	.6791	.7716	.7387
27	.014195	.1836	.5276	.5385	.6120	.5858
28	.012641	.1456	.4183	.4270	.4853	.4645
29	.011257	.1155	.3317	.3386	.3849	.3683
30	.010025	.0916	.2631	.2686	.3052	.2922
31	.008928	.0727	.2087	.2130	.2421	.2318
32	.007950	.0576	.1655	.1693	.1919	.1837
33	.007080	.0457	.1312	.1340	.1522	.1457
34	.006304	.0362	.1040	.1062	.1207	.1155
35	.005614	.0287	.0825	.0843	.0957	.0916
36	.005000	.0228	.0655	.0668	.0753	.0727
37	.004453	.0181	.0519	.0530	.0602	.0577
38	.003965	.0143	.0413	.0420	.0478	.0457
39	.003531	.0114	.0326	.0333	.0379	.0363
40	.003144	.0090	.0259	.0264	.0300	.0287
Specific Gravity		2.680	7.698	7.858	8.930	8.549
Weight per Cubic Foot		167.111	480.000	490.000	556.830	533.073

N O T E :

Water at 62 degrees F. weights 62.355 lbs per Cubic Foot.
Drawn Wrought Iron is 2.8724 times hevier than drawn Aluminum.
Drawn Steel is 2.9322 times heavier than drawn Aluminum.
Drawn Copper is 3.3321 times heavier than drawn Aluminum.
Drawn Brass is 3.1900 times heavier than drawn Aluminum.

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TABLE No. 5

COMPARATIVE WEIGHTS AND SIZES OF COPPER WIRE.

SPECIFIC GRAVITY - 8.89

No.	B. and S. Gauge.				Birmingham Gauge.				English Legal Standard Gauge.			
	Diam. Mils D	Area C.M. D^2	Weight. 1,000 Ft.	Weight. Mile.	Diam. Mils D	Area C.M. D^2	Weight. 1,000 Ft.	Weight. Mile.	Diam. Mils. D.	Area C.M. D^2.	Weight. 1,000 Ft.	Weight. Mile.
6 - 0									464.	215296.	651.6	3540.4
5 - 0									432.	186624.	564.8	2982.1
4 - 0	460.	211600.	640.4	3382.0	454.	206116.	623.9	3294.2	400.	160000.	484.2	2556.6
3 - 0	409.64	167800.	507.9	2682.0	425.	180625.	546.8	2887.1	372.	138384.	418.8	2111.3
2 - 0	364.80	133079.	402.8	2127.0	380.	144400.	437.1	2307.9	348.	121104.	366.5	1935.1
1 - 0	324.86	105534.	319.4	1686.5	340.	115600.	349.9	1847.5	324.	104976.	317.7	1677.4
1	289.30	83694.	253.3	1337.4	300.	90000.	272.4	1438.3	300.	90000.	272.4	1438.3
2	257.63	66373.	200.9	1016.7	284.	80656.	244.1	1288.8	276.	76176.	230.5	1217.0
3	229.42	52634.	159.3	841.10	259.	67081.	203.1	1072.4	252.	63504.	192.2	1014.8
4	204.31	41743.	126.3	666.86	238.	56644.	171.5	905.5	232.	53824.	162.9	860.1
5	181.94	33102.	102.0	529.05	220.	48400.	146.5	773.5	212.	44944.	136.0	718.1
6	162.02	26250.	79.45	419.59	203.	41209.	124.7	658.5	192.	36864.	111.6	589.2
7	144.29	20820.	63.01	332.69	180.	32400.	98.08	517.8	176.	30976.	93.75	495.0
8	128.49	16510.	49.97	263.84	165.	27225.	82.41	435.1	160.	25600.	77.48	409.1
9	114.42	13090.	39.63	209.24	148.	21904.	66.30	350.1	144.	20736.	62.76	331.8
10	101.90	10384.	31.42	166.00	134.	17956.	54.35	287.0	128.	16384.	49.59	261.8
11	90.74	8234.	24.92	131.57	120.	14400.	43.59	230.2	116.	13456.	40.73	215.1
12	80.81	6530.	19.76	104.33	109.	11881.	35.96	189.9	104.	10816.	32.73	172.8
13	71.96	5179.	15.67	82.74	95.	9025.	27.32	144.2	92.	8464.	25.62	135.3
14	64.08	4107.	12.43	65.63	83.	6889.	20.85	110.1	80.	6400.	19.37	102.3
15	57.07	3257.	9.85	52.00	72.	5184.	15.69	82.84	72.	5184.	15.69	82.84
16	50.82	2583.	7.817	41.27	65.	4225.	12.79	67.53	64.	4096.	12.40	65.47
17	45.26	2048.	6.199	32.73	58.	3364.	10.18	53.75	56.	3136.	9.491	50.11
18	40.30	1624.	4.916	25.96	49.	2401.	7.268	38.38	48.	2304.	6.973	36.82
19	35.89	1288.	3.899	20.59	42.	1764.	5.340	28.19	40.	1600.	4.842	25.57
20	31.96	1022.	3.092	16.33	35.	1225.	3.708	19.58	36.	1296.	3.922	20.71

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TABLE No. 5

(Concluded)

No.	B. and S. Gauge.				Birmingham Gauge.				English Legal Stardard Gauge.			
	Diam. Mils. D.	Area C. M. D^2	Weight.		Diam. Mils. D.	Area C. M. D^2	Weight.		Diam. Mils. D.	Area C. M. D^2	Weight.	
			1,000 Ft.	Mile.			1,000 Ft.	Mile.			1,000 Ft.	Mile.
21	28.46	810.1	2.452	13.00	32.	1024.	3.100	16.37	32.	1024.	3.100	16.37
22	25.35	642.5	1.944	10.26	28.	784.	2.373	12.53	28.	784.	2.373	12.53
23	22.57	509.5	1.542	8.14	25.	625.	1.892	9.99	24.	576.	1.743	9.20
24	20.10	404.1	1.223	6.46	22.	484.	1.465	7.74	22.	484.	1.465	7.74
25	17.90	320.4	.969	5.12	20.	400.	1.211	6.39	20.	400.	1.211	6.39
26	15.94	254.1	.769	4.06	18.	324.	.980	5.17	18.	324.	.980	5.17
27	14.20	201.5	.609	3.22	16.	256.	.775	4.09	16.4	269.	.814	4.30
28	12.64	159.8	.483	2.55	14.	196.	.593	3.13	14.8	219.	.663	3.50
29	11.26	126.7	.383	2.02	13.	169.	.512	2.70	13.6	185.	.560	2.96
30	10.03	105.0	.304	1.65	12.	144.	.436	2.30	12.4	153.8	.465	2.46
31	8.92	79.7	.241	1.27	10.	100.	.303	1.60	11.6	134.6	.407	2.15
32	7.95	63.20	.191	1.00	9.	81.	.245	1.29	10.8	116.6	.353	1.87
33	7.08	50.13	.151	.80	8.	64.	.194	1.02	10.0	100.	.303	1.60
34	6.30	39.75	.120	.63	7.	49.	.148	.781	9.2	84.6	.256	1.35
35	5.61	31.53	.0954	.50	5.	25.	.076	.401	8.4	70.5	.214	1.13
36	5.00	25.00	.0756	.40	4.	16.	.048	.253	7.6	57.7	.175	.924
37	4.45	19.80	.0600	.32					6.8	46.24	.139	.734
38	3.965	15.68	.0475	.25					6.0	36.00	.109	.576
39	3.531	12.46	.0377	.20					5.2	27.04	.081	.428
40	3.144	9.86	.0299	.16					4.8	23.04	.069	.364

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TABLE No. 6

TABLE OF WEIGHTS AND RESISTANCES OF PURE COPPER WIRE.

American Gauge B & S.	Area in C. M.	Area in Sq. In.	Lbs. per Mile.	Feet per Lb.	Resistance at 70° F.				Log. D²	Log. R.
					R Ohms Per 1000 Feet.	Ohms per Mile.	Feet per Ohm.	Ohms per Lb.		
4 - 0	211600.	.166190	3393.07	1.726	.049286	.26050	20290.	.00007668	5.325516	$\bar{2}$.692724
3 - 0	167800.	.131790	2690.75	2.179	.062148	.32813	16091.	.00012193	5.224808	$\bar{2}$.793427
2 - 0	133079.	.104520	2133.74	2.748	.078363	.41378	12718.	.00019390	5.124102	$\bar{2}$.894111
1 - 0	105534.	.082886	1692.14	3.465	.098816	.52174	10118.	.00030831	5.023394	$\bar{2}$.994827
1	83694.	.065733	1342.21	4.368	.12459	.65780	8026.0	.00049015	4.922688	1.095483
2	66373.	.052130	1064.39	5.508	.15712	.82960	6364.2	.00077940	4.821980	1.196231
3	52634.	.041339	843.96	6.946	.19824	1.0467	5044.5	.0012401	4.721274	1.217191
4	41743.	.032784	669.44	8.757	.24982	1.3191	4002.8	.0019706	4.620566	1.397627
5	33102.	.025998	530.79	11.044	.31504	1.6634	3174.2	.0031333	4.519860	1.498366
6	26250.	.020617	420.102	13.924	.39725	2.0974	2517.3	.0049830	4.419152	1.599064
7	20820.	.016349	333.93	17.556	.50099	2.6450	1996.2	.0079236	4.318446	1.699829
8	16510.	.012966	264.78	22.140	.63176	3.3355	1582.8	.0012599	4.217738	1.800552
9	13090.	.010284	209.90	27.931	.79643	4.2052	1255.6	.020026	4.117030	1.901148
10	10384.	.0081532	166.49	35.215	1.0047	5.3042	995.42	.031880	4.016324	0.002036
11	8234.	.0064670	132.04	44.39	1.2666	6.6878	789.58	.050650	3.915616	0.102639
12	6530.	.0051286	104.71	55.98	1.5971	8.4325	626.16	.080520	3.814910	0.203332
13	5179.	.0040671	83.02	70.595	2.0139	10.632	496.60	.12803	3.714202	0.304038
14	4107.	.0031469	65.83	89.02	2.5396	13.408	393.78	.20364	3.613496	0.404765
15	3257.	.0025578	52.22	112.27	3.1939	16.862	313.12	.32288	3.513788	0.504321
16	2583.	.0020286	41.42	141.55	4.0378	21.319	247.68	.51473	3.412082	0.606145
17	2048.	.0016086	32.85	178.47	5.0918	26.892	196.41	.81840	3.311374	0.706871
18	1624.	.0012757	26.04	225.14	6.4201	33.901	155.77	1.3006	3.210668	0.807542
19	1288.	.00101166	20.65	283.82	8.0860	42.692	123.67	2.0669	3.109960	0.907734
20	1022.	.0008022	16.38	357.91	10.209	53.900	97.962	3.2903	3.009254	1.008983

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TABLE No. 6

(Concluded)

American Gauge B & S.	Area in C. M.	Area in Sq. In.	Lbs. per Mile.	Feet per Llb.	Resistance at 70° F.				Log. D^2	Log. R.
					R. Ohms Per 1000 Feet	Ohms Per Mile.	Feet Per Ohm.	Ohms Per Llb.		
21	810.1	.00063625	12.99	451.38	12.873	67.970	77.685	5.2324	2.908456	1.109680
22	642.5	.00050478	10.30	569.10	16.228	85.679	61.634	8.3140	2.807838	1.210265
23	509.5	.00040012	8.169	717.66	20.471	108.08	48.851	13.232	2.707132	1.311139
24	404.1	.00031731	6.478	904.97	25.813	136.28	38.742	21.035	2.606424	1.411838
25	320.4	.00025164	5.138	1141.1	32.550	171.86	30.713	33.340	2.505718	1.512551
26	254.1	.00019950	4.075	1438.7	41.058	216.78	24.353	53.226	2.405010	1.613398
27	201.5	.00015826	3.230	1814.9	51.758	273.55	19.320	84.578	2.304304	1.713977
28	159.8	.00012550	2.562	2288.5	65.265	344.57	15.321	134.34	2.203596	1.814680
29	126.7	.000099526	2.032	2884.9	82.292	434.48	12.151	213.80	2.102890	1.915358
30	105.0	.000078933	1.612	3637.7	103.77	547.90	9.6374	339.98	2.002182	2.016072
31	79.7	.000062604	1.278	4585.9	130.82	690.70	7.6439	540.40	1.901476	2.116674
32	63.20	.000049637	1.013	5784.9	165.01	871.22	6.0602	859.42	1.800768	2.217510
33	50.13	.000039372	.8039	7292.9	208.03	1098.3	4.8071	1365.8	1.700060	2.318126
34	39.75	.000031212	.6373	9199.6	262.42	1385.5	3.8105	2188.9	1.599354	2.418997
35	31.53	.000024756	.5055	11627.4	330.85	1746.8	3.0226	3456.0	1.498646	2.519631
36	25.00	.000019635	.4010	14620.6	417.60	2202.5	2.3972	5494.2	1.397940	2.620303
37	19.80	.000015567	.3179	18440.0	525.86	2776.7	1.9017	8732.3	1.297234	2.720870
38	15.68	.000012347	.2521	23252.6	663.36	3502.4	1.5075	13892.	1.196526	2.821749
39	12.46	.0000097939	.1999	29331.9	836.23	4415.2	1.1958	22082.	1.095820	2.922326
40	9.86	.0000077676	.1584	37019.2	1054.3	5566.4	.9484	35100.	0.995 112	3.022964

NOTE:

Calculated on the basis of Dr. Matthiessen's Standard, viz: The resistance of a pure soft copper wire 1 meter long having a weight of 1 gram = .141729 International Ohms at 0° C.

Pure Copper weighs 556.830 lbs. per Cubic foot.

6 - 0
5 - 0
4 - 0
3 - 0
2 - 0
1 - 0
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TABLE No. 7

TABLE OF RESISTANCES OF PURE COPPER WIRE.

	B. AND S.		BIRMINGHAM GAUGE.		ENGLISH LEGAL STANDARD.	
	Resistance per 1,000 Feet. International Ohms.		Resistance per 1,000 Feet. International Ohms.		Resistance per 1,000 Feet. International Ohms.	
	At 60° F.	At 75° F.	At 60° F.	At 75° F.	At 60° F.	At 75° F.
6 - 0					.04729	.04880
5 - 0					.05455	.05630
4 - 0	.04811	.04886	.04939	.05098	.06363	.06567
3 - 0	.06056	.06251	.05636	.05817	.07357	.07593
2 - 0	.07642	.07887	.07050	.07277	.08407	.08676
1 - 0	.09639	.09948	.08807	.09089	.09698	.10009
1	.12190	.1258	.1131	.1167	.1131	.11670
2	.1529	.1579	.1262	.1303	.1336	.1379
3	.1941	.2004	.1518	.1566	.1303	.1655
4	.2446	.2525	.1797	.1855	.1892	.1952
5	.3074	.3172	.2103	.2171	.2265	.2338
6	.3879	.4004	.2471	.2550	.2762	.2850
7	.4910	.5067	.3142	.3243	.3287	.3392
8	.6214	.6413	.3739	.3859	.3977	.4104
9	.7834	.8085	.4648	.4797	.4910	.5067
10	.9785	1.010	.5670	.5852	.6214	.6413
11	1.229	1.269	.7070	.7297	.7566	.7809
12	1.552	1.601	.8569	.8844	.9413	.9715
13	1.964	2.027	1.128	1.164	1.203	1.241
14	2.485	2.565	1.478	1.525	1.591	1.642
15	3.133	3.234	1.964	2.027	1.964	2.037
16	3.914	4.040	2.410	2.487	2.486	2.565
17	5.028	5.189	3.026	3.123	3.246	3.351
18	6.363	6.567	4.240	4.376	4.419	4.561
19	7.855	8.108	5.771	5.957	6.363	6.567
20	9.942	10.26	8.311	8.577	7.855	8.108
21	12.53	12.94	9.942	10.26	9.942	10.26
22	15.90	16.41	12.99	13.40	12.99	13.40
23	19.93	20.57	16.29	16.81	17.67	18.24
24	25.20	26.01	21.03	21.71	21.03	21.71
25	31.77	32.79	25.45	26.27	25.45	26.27
26	40.27	41.56	31.42	32.43	31.42	32.43
27	50.49	52.11	39.77	41.04	37.85	39.07
28	64.13	66.18	51.94	53.61	46.48	47.97
29	79.73	82.29	60.24	62.17	55.04	56.81
30	101.80	105.1	70.70	72.97	66.21	68.34
31	128.5	132.7	108.0	105.1	75.66	78.09
32	159.1	164.2	125.7	129.7	87.28	90.08
33	202.0	208.4	159.1	164.2	101.8	105.1
34	256.5	264.7	207.8	214.4	120.3	124.1
35	324.6	335.1	407.2	420.3	144.3	148.9
36	407.2	420.3	636.3	656.7	176.3	181.9

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TABLE No. 8

TABLE OF WEIGHTS AND RESISTANCES OF PURE ALUMINUM WIRE.

American Gauge B.& S	Area in C. M.	Area in Sq. In.	Lbs. Per Mile.	Feet per Llb.	Resistance at 70° F.				Log. D^2	Log. R.
					R. Ohms Per 1000 Feet.	Ohms Per Mile.	Feet Per Ohm.	Ohms Per Llb.		
4 - 0	211600.	.166190	1018.3	5.185	.07904	.41730	12652.	.00040985	5.325516	$\bar{2}$.897847
3 - 0	167800.	.131790	807.52	6.539	.09966	.52623	10034.	.00065102	5.224808	$\bar{2}$.998521
2 - 0	133079.	.104520	640.36	8.246	.12569	.66362	7956.	.0010364	5.124102	$\bar{1}$.099301
1 - 0	105534.	.082886	507.83	10.397	.15849	.83684	6310.	.0016479	5.023394	$\bar{1}$.200002
1	83694.	.065733	402.81	13.108	.19982	1.0552	5005.	.0026194	4.922688	$\bar{1}$.300639
2	66373.	.052130	319.44	16.529	.25200	1.3305	3968.	.0041656	4.821980	$\bar{1}$.401401
3	52634.	.041339	253.55	20.846	.31778	1.6779	3147.	.0066250	4.721274	$\bar{1}$.502127
4	41743.	.032784	200.90	26.281	.40067	2.1156	2496.	.010531	4.620566	$\bar{1}$.602787
5	33102.	.025998	159.30	33.146	.50526	2.6679	1975.	.016749	4.519860	$\bar{1}$.703515
6	26250.	.020617	126.35	41.789	.63720	3.3687	1569.	.026628	4.419152	$\bar{1}$.804276
7	20820.	.016349	100.21	52.687	.80350	4.2425	1245.	.042335	4.318446	$\bar{1}$.904986
8	16510.	.012966	79.46	66.445	1.0131	5.3498	987.	.067318	4.217738	0.005652
9	13090.	.010284	62.99	83.822	1.2773	6.7442	783.	.10710	4.117030	0.106293
10	10384.	.0081532	49.95	105.68	1.6111	8.5065	620.8	.17028	4.016324	0.207122
11	8234.	.0064670	39.63	133.24	2.0318	10.723	492.4	.27061	3.915616	0.307753
12	6530.	.0051286	31.43	168.01	2.5615	13.525	390.5	.43040	3.814910	0.408494
13	5179.	.0040671	24.92	211.86	3.2300	17.055	309.6	.68437	3.714202	0.509203
14	4107.	.0031469	19.76	267.17	4.0724	21.502	245.6	1.0877	3.613496	0.609850
15	3257.	.0025578	15.67	336.93	5.1354	27.114	194.8	1.7308	3.513788	0.710574
16	2583.	.0020286	12.43	424.81	6.4755	34.190	154.4	2.7505	3.412082	0.811273
17	2040.	.0016086	9.857	535.62	8.1670	43.124	122.5	4.3746	3.311374	0.912063
18	1624.	.0012757	7.814	675.67	10.300	54.388	97.10	6.9590	3.210668	1.012837
19	1288.	.00101166	6.199	851.79	12.985	68.564	77.05	11.070	3.109960	1.113442
20	1022.	.0008022	4.916	1074.11	16.381	86.500	61.06	17.595	3.009254	1.214340

(Continued)

American Gauge B.& S.
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TABLE No. 8

(Concluded)

American Gauge B.& S.	Area in C. M.	Area in Sq. In.	Lbs. Per Mile.	Feet Per Llb.	Resistance at 70° F.				Log. D^2	Log. R.
					R. Ohms Per 1000 Feet.	Ohms Per Mile.	Feet Per Ohm.	Ohms Per Llb.		
21	810.1	.00063625	3.898	1354.65	20.649	109.02	48.43	27.971	2.908546	1.314899
22	642.5	.00050478	3.091	1707.94	26.025	137.42	38.44	44.450	2.807838	1.415391
23	509.5	.00040012	2.451	2153.78	32.830	173.35	30.45	70.700	2.707132	1.516271
24	404.1	.00031731	1.944	2715.91	41.400	218.60	24.16	112.43	2.606424	1.617000
25	320.4	.00025164	1.542	3426.66	52.200	275.61	19.16	178.78	2.505718	1.717671
26	254.1	.00019950	1.223	4317.78	65.856	347.70	15.19	284.36	2.405010	1.818596
27	201.5	.00015826	.9694	5446.63	83.010	438.32	12.05	452.62	2.304304	1.919130
28	159.8	.00012550	.7688	6868.13	104.67	552.64	9.55	718.95	2.203596	2.019822
29	126.7	.000099526	.6098	8698.03	132.00	697.01	7.58	1142.9	2.102890	2.120574
30	105.	.000078933	.4836	10917.	166.43	878.8	6.01	1817.2	2.002182	2.221232
31	79.7	.000062604	.3836	13762.8	209.85	1108.0	4.77	2888.0	1.901476	2.321909
32	63.2	.000049637	.3041	17361.1	264.68	1397.6	3.78	4595.5	1.800768	2.422721
33	50.13	.000039372	.2412	21886.7	333.68	1760.2	3.00	7302.0	1.700060	2.523330
34	39.75	.000031212	.1912	27609.1	420.87	2222.2	2.38	11627.	1.599354	2.624148
35	31.53	.000024756	.1517	34807.3	530.60	2801.8	1.88	18440.	1.498646	2.724767
36	25.00	.000019635	.1203	43878.9	669.00	3532.5	1.50	29352.	1.397940	2.825425
37	19.80	.000015567	.0954	55340.4	843.46	4453.0	1.19	46600.	1.297234	2.926064
38	15.68	.000012347	.0757	69783.7	1064.0	5618.0	.95	74240.	1.196526	3.026942
39	12.46	.0000097939	.0600	88028.2	1341.2	7082.0	.75	118070.	1.095820	3.127494
40	9.86	.0000077676	.0475	111099.	1691.1	8930.0	.59	187700.	0.995112	3.228169

NOTE:

Calculated on the basis of Dr. Matthiessen's Standard, viz:
The resistance of a pure soft copper wire 1 meter long and having the weight of 1 gram is .141729 International Ohms at 0° C.

Pure Aluminum weights 167.111 pounds per cubic foot.

TABLE No. 9

TENSILE STRENGTH OF COPPER WIRE.

Number of Wire B.and S. Gauge.	Breaking Weight of Hard Drawn. Pounds.	Breaking Weight of Annealed. Pounds.
4 - 0	9971.	5650.
3 - 0	7907.	4480.
2 - 0	6271.	3553.
1 - 0	4973.	2818.
1	3943.	2234.
2	3127.	1772.
3	2480.	1405.
4	1967	1114.
5	1559.	883.
6	1237.	700.
7	980.	555.
8	778.	440.
9	617.	349.
10	489.	277.
11	388.	219.
12	307.	174.
13	244.	138.
14	193.	109.
15	153.	87.
16	133.	69.
17	97.	55.
18	77.	43.
19	61.	34.
20	48.	27.

TABLE No.10

GALVANIZED TELEPHONE AND TELEGRAPH WIRE.

(UNCOVERED)

Number B.W. Gauge.	Diameter in Inches.	Weight - Pounds		Breaking Strength Pounds		Resistance per Mile In Ohms.		
		1000 Feet.	One Mile.	Iron.	Steel.	E.B.B.	B.B.	Steel.
1 - 0	.340	304.	1607.	4821.	9079.	2.93	3.42	4.05
1	.300	237.	1251.	3753.	7068.	3.76	4.40	5.20
2	.284	212.	1121.	3363.	6335.	4.19	4.91	5.80
3	.259	177.	932.	2796.	5268.	5.04	5.90	6.97
4	.238	149.	787.	2361.	4449.	5.97	6.99	8.26
5	.220	127.	673.	2019.	3801.	6.99	8.18	9.66
6	.203	109.	573.	1719.	3237.	8.21	9.60	11.35
7	.180	85.	450.	1350.	2545.	10.44	12.21	14.43
8	.165	72.	378.	1134.	2138.	12.42	14.53	17.18
9	.148	58.	305.	915.	1720.	15.44	18.06	21.35
10	.134	47.	250.	750.	1410.	18.83	22.04	26.04
11	.120	38.	200.	600.	1131.	23.48	27.47	32.47
12	.109	31.	165.	495.	933.	28.46	33.30	39.36
13	.095	24.	125.	375.	709.	37.47	43.85	51.82
14	.083	18.	96.	288.	541.	49.08	57.44	67.88
15	.072	13.7	72.	216.	407.	65.23	76.33	90.21
16	.065	11.1	59.	177.	332.	80.03	93.66	110.7
17	.058	8.9	47.	141.	264.	100.5	120.4	139.
18	.049	6.3	33.	99.	189.	140.8	164.8	194.8

TABLE No.11

MUSIC WIRE GAUGES COMPARED.

Number of Gauge,	American Manufacturers. In Inches.	German Manufacturers. In Inches.
4 - 0.	.007	.0068
3 - 0	.0075	.0075
2 - 0	.0085	.0087
1 - 0	.009	.0093
1	.010	.0098
2	.011	.0106
3	.012	.0114
4	.013	.0122
5	.014	.0138
6	.016	.0157
7	.018	.0177
8	.020	.0197
9	.022	.0216
10	.024	.0236
11	.026	.0260
12	.028	.0283
13	.030	.0303
14	.032	.0323
15	.034	.0342
16	.036	.0362
17	.038	.0382
18	.040	.040
19	.042	.042
20	.044	.044
21	.046	.046
22	.048	.048
23	.051	.051
24	.055	.055
25	.059	.059
26	.063	.063
27	.067	.067
28	.071	.071
29	.074	.074
30	.078	.078
31	.082	.082
32	.086	.086
33	.090	.091

TABLE No.12

RESULTS OF TESTS ON PIANO WIRE.

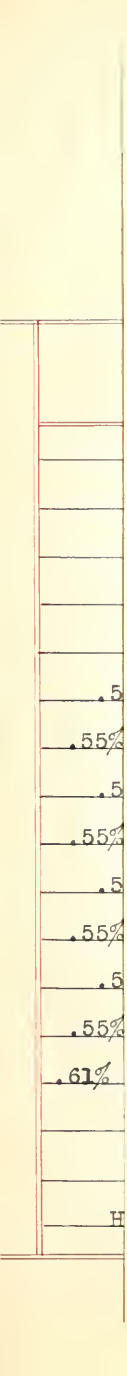
Gauge Number.	Diameter in Inches.	Maximum Load in Pounds.	Maximum Load in Pounds Per Square Inch.	Elongation in 12 Inches.
POHLMANN WIRE COMPANY.				
13	.0303	263.	364590.	.1816
14	.0323	282.	344000.	.201
15	.0342	355.	386200.	.2005
16	.0362	363.	352500.	.2330
17	.0382	396.	345300.	.2051
18	.0400	402.	319800.	.2022
19	.0420	423.	305200.	.2332
20	.0440	461.	303100.	.2314
FELTON AND GUILLEAUME WIRE COMPANY.				
13	.0303	270.	374300.	.1882
14	.0323	290.	353800.	.2531
15	.0342	340.	369900.	.2000
16	.0362	377.	366100.	.2620
17	.0382	424.	369000.	.2199
18	.0400	443.	352400.	.2499
19	.0420	480.	347000.	.2606
20	.0440	527.	346400.	.2841
AMERICAN STEEL AND WIRE COMPANY.				
13	.030	295.	417200.	.2109
14	.032	336.	417600.	.2132
15	.034	357.	393000.	.2259
16	.036	400.	392800.	.2075
17	.038	423.	372800.	.2132
18	.040	460.	365900.	.2250
19	.042	519.	374300.	.2368
20	.044	525.	345100.	.2408

TABLE No.13

RESULTS OF TESTS OF GALVANIZED TELEPHONE WIRE.

SAMPLES FURNISHED BY INDIANA STEEL AND WIRE COMPANY.

Gauge Number.	Diameter in Inches.	Maximum Load in Pounds.	Elongation In Inches Per Foot.	Per-cent Elongation.	Resistance In Ohms Per Mile at 60° F.	Torsion. Number of Complete Turns in 6".
			S T E E L			
10	.134	897.	2.08	17.3	24.37	22.
12	.109	571.	1.85	15.4	33.32	45.
14	.083	333.	2.16	18.0	58.5	46.
			B. B.			
10	.134	866.	1.82	15.2	21.65	29.
12	.109	557	1.92	16.0	33.41	41.
14	.083	334.	1.97	16.4	57.94	38.
			E. B. B.			
10	.134	876.	1.73	14.4	21.69	30.
12	.109	535.	1.67	13.9	36.03	44.
14	.083	328.	1.93	16.1	56.48	36.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A P P E N D I X.

TABLE No.14

RESULTS OF TESTS ON VARIOUS SAMPLES OF IRON AND STEEL WIRE

RECEIVED FROM THE PAGE WOVEN WIRE FENCE COMPANY.

Description.	W. & M. Gauge Number.	Diameter in Inches.	Maximum Breaking Load.	Breaking Load In Pounds Per Sq. Inch.	Elongation in 12 Inches.	Per-Cent Elongation.
Iron Wire	9	.1483	1398.	80900.	.13	1.83
Iron Wire	10	.1350	1224.	85500.	.13	1.83
Iron Wire	11	.1205	998.	87400.	.12	1.00
Iron Wire	12	.1055	796.	91200.	.07	.583
Iron Wire	14	.0800	514.	102800.	.18	1.5
.55% Carbon. (Annealed)	-	.375	13891.	125700.	1.12	9.24
.55% Carbon. (Not Annealed)	-	.375	15330.	140600.	.26	2.165
.55% Carbon. (Annealed)	-	.250	9572.	194900.	.30	2.5
.55% Carbon. (Not Annealed)	-	.250	8584.	174800.	.10	.833
.55% Carbon. (Annealed)	5	.2070	6493.	192900.	.76	6.33
.55% Carbon. (Not Annealed)	5	.2070	5991.	178000.	.245	2.04
.55% Carbon. (Annealed)	11	.1205	2500.	219100.	.3365	2.805
.55% Carbon. (Not Annealed)	11	.1205	2119.	185700.	.3405	2.838
.61% Carbon. - .85% Manganese	-	.21875	4532.	120600.	1.04	8.67
Basic. - .1% Carbon	7	.1770	2175.	88390.	.15	1.25
Basic. - .1% Carbon	12	.1055	993.	113500.	.09	.75
High Carbon Rope Wire	18	.0475	377.	212700.	.2258	1.88

DATA USED IN THE COMPILING OF THE TABLES WAS SELECTED FROM THE FOLLOWING MANUFACTURERS CATALOGUES:

Cary Spring Works.

Hazard Manufacturing Company.

Wright & Cotton Wire Cloth Company.

John A. Roebling's Sons Company.

Spencer Wire Company.

Pittsburg Reduction Company.

Chicago Insulated Wire Company.

Also,

Kents Mechanical Engineers Hand-book.

L. A. Paradise.

G. W. Clucas.